J Occup Health 2008; 50: 75–78

Case Study

Simultaneous Observation of Zero-Value of FSBP% and Raynaud's Phenomenon during Cold Provocation in Vibration Syndrome

Yutaka Fujiwara[1], Satoshi Yoshino[2] and Yoshiro Nasu[3]

[1]Department of Internal Medicine, [2]Department of Clinical Laboratory, Bibai Rosai Hospital and [3]Clinical Research Center for Hand-Arm Vibration Syndrome, Japan Labor, Health and Welfare Organization, San-in Rosai Hospital, Japan

Key words: Hand-arm vibration syndrome, Raynaud's phenomenon, FSBP%

Many workers using vibratory tools suffer from hand-arm vibration syndrome. Among symptoms of the syndrome, blanching attack is the most typical. In terms of medico-legal aspects, objective recognition of Raynaud's phenomenon is considered to be most important in judging the syndrome as an occupational disease.

Measurement of finger systolic blood pressure test (FSBP%) in the laboratory has recently been introduced in Europe to confirm the occurrence of vibration-induced white finger. During the epidemiological study at the Stockholm Workshop 1994, the following points were agreed upon in making a confirmation of the occurrence of blanching attack: recognition of white finger during a doctor's inspection, color pictures of the hands photographed together with the patient's face and measurement of zero-value of FSBP%. Even if workers complain of blanching attacks in the fingers, if Raynaud's phenomenon cannot be confirmed under these criteria, registration of these cases must be judged as cases of unidentified phenomenon. However, it is very difficult to confirm Raynaud's phenomenon under direct inspection by a doctor or with color photographs because of the rapid disappearance of attacks. In addition, it is rare that FSBP% shows zero-value in a laboratory. Theoretically, a zero-value of FSBP% indicates complete closure of the digital arteries resulting in a blanching attack. We report the simultaneous observation of both zero-value of FSBP% and blanching attack during cold provocation test.

Case Presentation

Our patient was a 66-yr-old man living in the central part of Hokkaido, where the average outside temperature is –20℃ in winter and there are only a few warm days of around 20℃ in summer. He had suffered from diabetes mellitus since he was 50 yr old, but his blood sugar level had been well controlled (HbA_{1c} 4.8%) without any diabetic angiopathy or neuropathy. In this case diabetes mellitus had no effect to the peripheral circulation in hand-arm vibration syndrome. Except for diabetes mellitus, other diseases such as collagen disease, neurological disease, obstructive vascular disease, cardiovascular and metabolic diseases were not found. His height was 160 cm and his body weight was 54.5 kg.

He started to use a pick hammer in a coal mine when he was 22 yr old. His first blanching attack occurred when he was 27 yr old after 5 yr of using vibratory tools. Because of the appearance of white finger, he was recognized as a patient with vibration syndrome in accordance with the Worker's Accident Compensation Insurance Law. However, he continued to use vibratory tools even after the official recognition. He completely ceased the use of vibratory tools at 31 yr old. Even after the complete cessation of working with vibratory tools and even after continued treatment with vasoactive drugs and physiotheray, blanching attacks in the fingers of both his hands except for his thumbs had continued to occur, even in the summer. White finger was confirmed by doctor's inspection several times. After cessation of the use of vibratory tools, he had not done any physical work and had been receiving unemployment compensation. His vascular stage was classified as stage 3 of the Stockholm scale in both hands.

The test procedure of the present study was explained to the patient prior to the experiment and written informed consent was obtained from him. In January, 2005, we made measurements of finger skin temperature after the patient rested for more than 30 min in an artificially controlled climate with a room temperature of 21℃ and 50% of relative humidity. He was wearing two shirts and a pair of trouser and socks[1)]. FSBP% of all fingers in the right hand were measured simultaneously with a HVLab multi-channel plethysmograph (Human Factors Research Unit, Institude of Sound and Vibration Research, University of Southampton, Highfield, Southampton SO17 1BJ, United Kingdom). The HVLab multi-channel plethysmograph provides computer-based measurement of finger systolic blood pressure during simultaneous cold provocation of all the test fingers. Finger systolic blood pressures measured at different temperatures can be used to detect problems in the vascular response to cold. The HVLab multi-channel plethysmograph consists of a single unit containing signal processing, pressure control and temperature control systems. Pressure cuffs and transducers designed for measurement of finger systolic blood pressures are the attached to the HVLab multi-channel plethysmograph. This system is controlled using

Received Mar 7, 2007; Accepted Aug 29, 2007
Correspondence to: Y. Fujiwara, Atsubetsukita 3-Jo 5-Chome 17–5, Atsubetsu-ku, Sapporo 004-0073, Japan (e-mail: y-fuji@dg8.so-net.ne.jp)

Fig. 1. Photograph of the dorsal side of the right hand. The middle and ring finger show Raynaud's phenomenon. On the dorsal side of the little finger, patches of white can be seen.

Fig. 2. Photograph of the palm side of the right hand. The middle and ring finger show Raynaud's phenomenon. On the palm side of the little finger, no patches of white can be seen.

software installed on an computer interface card. The system controls finger temperature by rapid heating and cooling of water flowing through specially designed pressure cuffs.

At the start of measurement, water with a temperature of 30℃ was used to obtain control values of FSBP%. After that, water at 15℃ was used[2]. At the final stage of cold provocation with water at 15℃ for 5 min, Raynaud's phenomenon was confirmed and photos of his hands were taken. The phenomenon appeared on the distal parts extending outwards from the proximal phalanx of the index, middle, and ring fingers. Figures 1 and 2 show Raynaud's phenomenon observed after cold provocation of 15℃. In these pictures, Raynaud's phenomenon is seen clearly only in the middle and ring fingers. Immediately after the appearance, rapid recovery occurred in the right index finger. Therefore, we could not get a picture of Raynaud's phenomenon in the index finger.

In Figs. 3 (a) and (b) , volume-pressure plots for the measurement of finger systolic blood pressure at 30℃ and 15℃ are shown respectively. During the cooling period, the fingers were maintained in an ischemic state by means of a pressure cuff, inflated to suprasystolic pressure. At the end of the period of cold provocation, the pressure in the cuffs was slowly released until blood re-entered the fingers. Finger systolic blood pressures of each finger was defined as the highest cuff pressure at which arterial inflow resulted in an increase in the volume of the distal phalanx of the fingers, indicated by the strain gauge signal. Each closed circle indicates the first increase in the arterial flow after deflating the occlusion cuff. The blood pressure in the reference finger served as a control and was obtained without cooling, using a single-inlet air cuff placed on the medial phalanx of the reference finger (proximal phalanx of the thumb). As shown in Fig. 3 (a), remarkable increases in the arterial flow after deflating the occlusion cuff were detected in the thumb, index, middle, ring and little fingers. As shown in Fig. 3 (b), increases were not detected in the middle, ring and little fingers. Slight increased arterial flow was detected in the index finger recovering from the blanching attacks. Values of FSBP% were calculated automatically with a computer connected to the plethysmograph, according to the formula[3]. In Table 1, values of finger skin temperature, values of finger systolic blood pressure, situation of Raynaud' phenomenon at cold provocation test of 30℃ and 15℃, and values of FSBP% are shown. Values of FSBP% were 23.1% in the index finger and 0% in the middle, ring, and little fingers.

On the same day, the finger skin temperature was measured with an E 8105 thermocouple thermometer (Cole-Palmer Instruments) to an accuracy of 0.1℃ . The range of finger skin temperature at rest was from 23.0 to 24.7℃. The results of the cold water immersion test of 10℃ for 10 min showed 23% and 28% of recovery rate at 5 and 10 min after the immersion, respectively. During the cold immersion test Raynaud's phenomenon was not comfirmed.

Discussion

Zero value of FSBP% indicates complete closure of the digital arteries. Therefore, it is considered that zero value of FSBP% confirms Raynaud's phenomenon in a laboratory. FSBP% is also known to show higher sensitivity and specificity for diagnosis of vibration-induced white finger, than a cold water immersion test[4–7]. In this case the FSBP% value of the little finger was 0%. However, Raynaud's phenomenon was not clearly

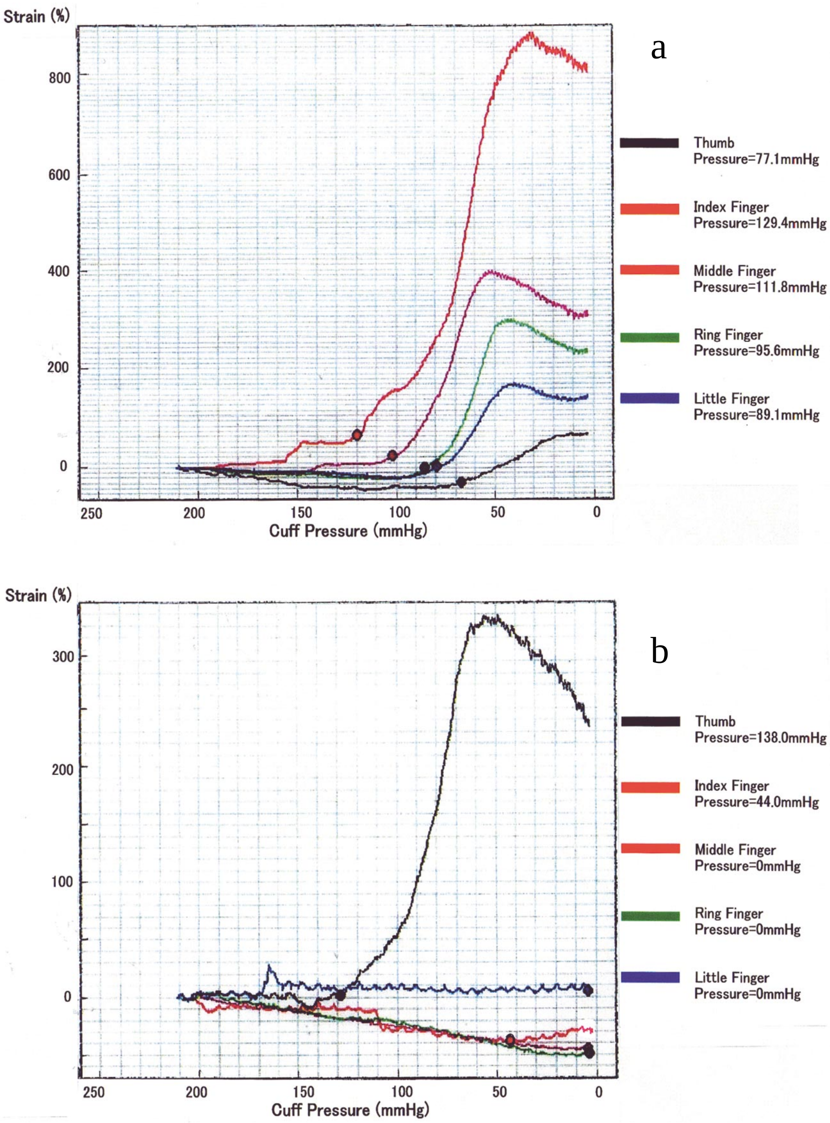

Fig. 3. Volume-pressure plot for the measurement of finger systolic blood pressure at 30℃ (a) and 15℃ (b). Arterial inflow is permitted when cuff pressure is equal to, or less than, systolic pressure. Inflow is detected by an increase in volume indicated by the strain gauge signal. The closed circle (●) indicates the beginning of each arterial inflow.

Table 1. Situation of Raynaud's phenomenon, skin temperature values, values and percentages of finger systolic blood pressure at cold provocation test of 30℃ and 15℃

Finger	Thumb	Index	Middle	Ring	Little
Raynaud's phenomenon					
Previous year	–	+(1.2.3)	+(1.2.3)	+(1.2.3)	+(1.2)
Present year	–	+(1.2)	+(1.2)	+(1.2)	+(1.2)
Skin temperature (℃)	23.4	21.6	22.1	21.4	21.7
Finger systolic blood pressure (mmHg)					
at 30℃	77.1	129.4	111.8	93.5	89.1
at 15℃	138.0	44.0	0	0	0
FSBP% at 15℃	100	23.1	0	0	0

1: distal phalanx, 2: middle phalanx, 3: proximal phalanx.
For example: + (1.2) indicates Raynaud's phenomenon on the distal part from the proximal interphalangeal joint.

observed in the little finger. A more detailed observation of the color picture showed patches of white color on the dorsal side of the finger, resulting from the rapid recovery phase of Raynaud's phenomenon.

The result of the cold water immersion test at 10℃ for 10 min showed no severe damage to the peripheral circulation. The cold immersion test cools fingers more thoroughly than the FSBP test, but may not induce severe digital vasospasms resulting in complete closure of the digital arteries.

Using the HVLab multi-channel plethysmograph, our observation indicated directly and clinically that zero pressure of FSBP% was consistent with Raynaud's phenomenon. When the study of FSBP% was started about 23 yr ago at San-in Rosai Hospital, Nasu's colleague, Dr. Kurozawa, observed Raynaud's phenomenon in a severe case of vibration syndrome[8, 9]. However, at that time color pictures were not taken, so the confirmation of the physiological provocation of Raynaud's phenomenon was obscure. Thus this may be the first report in which a zero value of FSBP% was observed in conjunction with color pictures taken indicating Raynaud's phenomenon.

In Japan, 6 units of DM2000 strain-gauge plethysmograph with 2 channels, made by Medimatic Co, are now used at 6 Rosai Hospitals for clinical research of vibration-induced white finger. With the 2-channel plethysmograph, we have rarely observed Raynaud's phenomenon induced by cold provocation at 10℃ for 5 min, using the segmental cooling procedure. In this case, we had a chance to use a HVLab multi-channel plethysmograph unit and could observe the zero value of FSBP% and blanching attack simultaneously during the cold provocation test. There may be a great difference in the degree of cold provocation between the 2-channel plethysmograph unit and the HVLab multi-channel plethysmograph unit, even though a temperature of 15℃ was utilized for provocation by both units. The former can cool only one finger at a time while the latter can cool 4 fingers simultaneously. Therefore, the hemodynamically important stenosis of each artery in all fingers may be investigated more precisely with a multi-channel plethysmograph than with a 2-channel plethysmograph.

In Japan, there is currently a plan to introduce the measurement of FSBP% for diagnosis of vibration-induced white finger and for the clinical research of hand-arm vibration syndrome. We assert that the measurement of FSBP% should be used rather than the cold water immersion test in order to make more detailed diagnosis. We further suggest that multi-channel plethysmography gives us more information than the 2-channel plethysmography because it can measure FSBP% in four fingers and the thumb simultaneously.

Acknowledgment: This research is a part of the research and development on the 13 fields of occupational injuries and illness of the Japan Labor Health and Welfare Organization and also a part of the assigned research study of the Japanese Ministry of Health, Labour and Welfare. We thank Prof. Miyashita at Wakayama Medical University for giving us a chance.

References

1) Mechanical vibration and shock- cold provocation tests for the assessment of peripheral vascular function. Part 1: Measurement and evaluation of finger skin temperature. International Standard ISO 14835–1, 2005.
2) Mechanical vibration and shock- cold provocation tests for the assessment of peripheral vascular function. Part 2: Measurement and evaluation of finger systolic blood pressure. International Standard ISO 14835–2, 2005.
3) Nielsen SL: Raynaud's phenomenon and finger systolic blood pressure during cooling. Scand J Clin Lab Invest 38, 765–770 (1997)
4) Nasu Y and Kurozawa Y: Comparison of the diagnostic values of three provocation tests for vibration white finger. Arete OCH HÄLSA 5, 109–116 (1995)
5) Bovenzi M: Finger systolic blood pressure during local cooling in normal subjects aged 20 to 60 years. Int Arch Occup Environ Health 61, 179–181 (1988)
6) Bovenzi M: Digital arterial responsiveness to cold in healthy men, vibration white finger and primary Raynaud's phenomenon. Scand J Work Environ Health 19, 271– 276 (1993)
7) Bovenzi M: Finger systolic blood pressure indices for the diagnosis of vibration-induced white finger. Int Arch Occup Environ Health 75, 20–28 (2002)
8) Kurozawa Y, Nasu Y and Nose T: Diagnostic value of finger systolic blood pressure in the assessment of vasospastic reactions in the finger skin of vibration-exposed subjects after finger and body cooling. Scand J Work Environ Health 17, 184–189 (1991)
9) Kurozawa Y, Nasu Y and Osino H: Finger systolic blood pressure measurements after finger cooling using the laser-Doppler method for assessing vibration induced white finger. J Occup Med 34, 683–686 (1992)